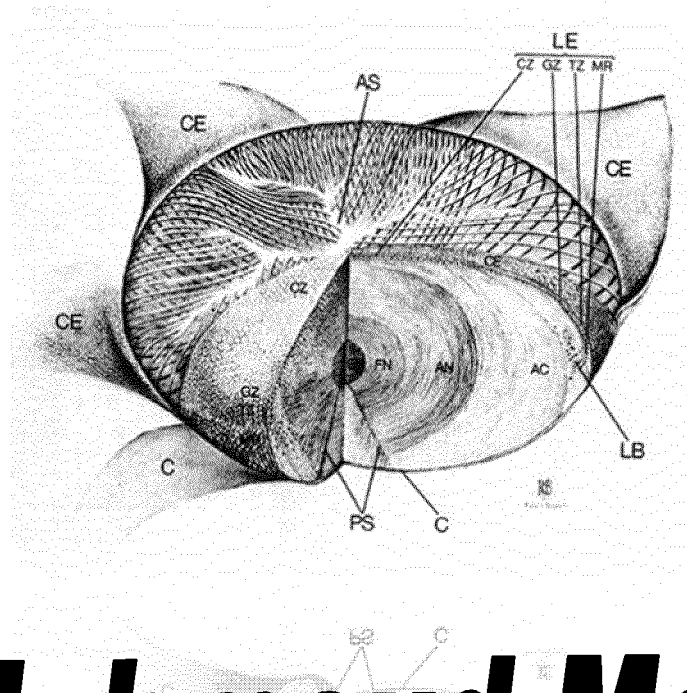


Ophthalmology

7

Crystalline Lens



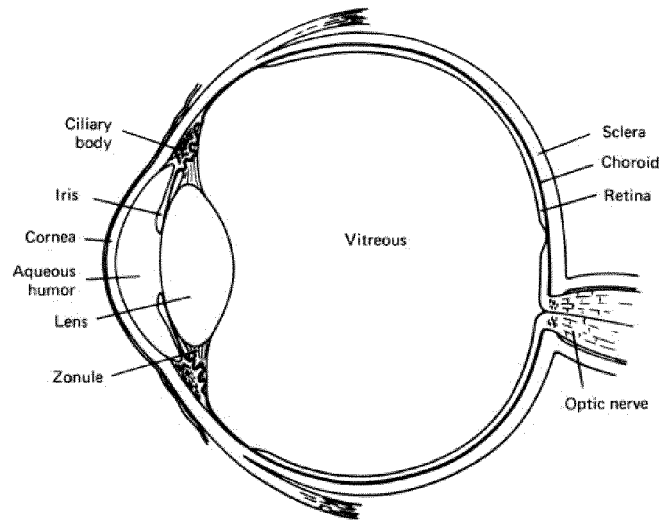
Dr/ Mahmoud Medhat

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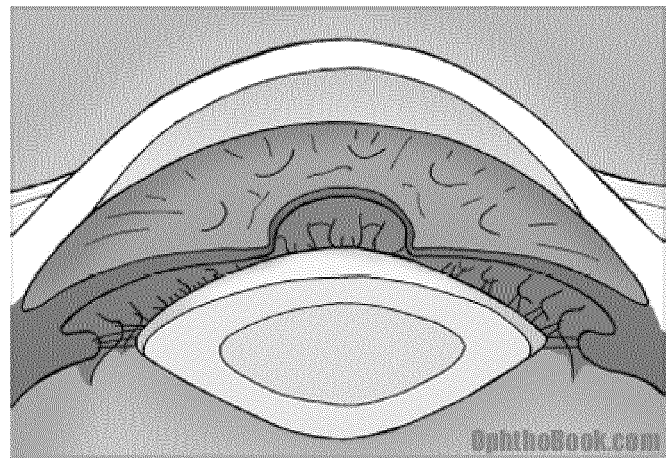
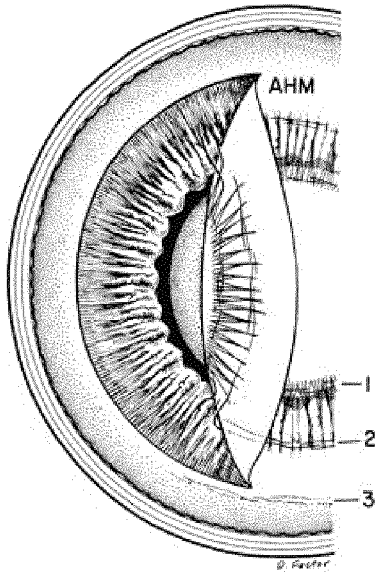
To the only one who gave me **HOPE**

Gross anatomy

The lens is a highly organized, biconvex, avascular, transparent structure of crystalline appearance. It alters the refractive index of light entering the eye. It is formed of a gelatinous substance & an elastic capsule.



Site: The lens is kept in its place, between the iris anteriorly & the vitreous posteriorly, by the suspensory ligaments (zonules of Zinn). These are fibers running from the inner surface of the ciliary body to the equator of the lens.



Surface landmarks

1. Anterior surface:

- Less curved than the posterior surface.
- Its center is the anterior pole.

- It is related to: Ciliary processes, posterior surface of the surface, posterior chamber & the anterior chamber through the pupil.

2. Posterior surface:

- More curved than the anterior surface.
- Separated from the vitreous by the retrolental space.

3. Equator: Meeting of the anterior & the posterior surfaces.

Dimensions of the human lens

Equatorial diameter: 9-10mm (6.5mm at birth).

Thickness:

- At birth: 3.5-4mm.
- 50 Years: 4mm.
- Extreme old age: 5mm.

Radius of curvature:

- Anterior surface: 10mm.
- Posterior surface: 6mm.

Refractive index: 1.39

Dioptric power: (*Inside the eye*): +15D.

Accommodative power: Varies with age:

- At birth: 15-16D.
- 50 Years of age: 1-2D.

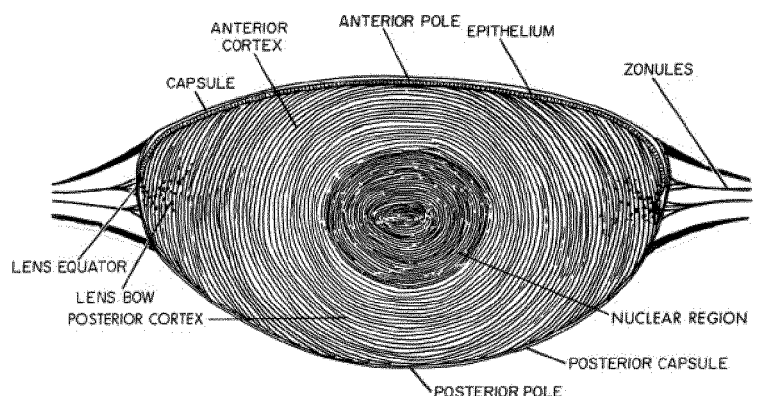
Minute anatomy

Minute anatomy of the lens:

1. Lens capsule.
 - Nucleus.
 - Cortex.
2. Lens epithelium.
3. Lens substance:

I. Capsule

- This is an elastic acellular envelope, ensheathing the lens matter. *It is like a bag, containing the lens epithelium & fibers.* It is important to regulate the passage of the small molecules from & into the lens matter.



- **Thickness:** The thickest part is that near the equator, the anterior pole is of intermediate thickness and the posterior pole is the thinnest area of the capsule.
- As the lens is avascular structure, passage of molecules through the lens capsule is the main route for getting nutrients and elimination of metabolites. Impaired permeability of the capsule results in loss of the lens clarity (Cataract.) and interference with vision.

N.B. The lens capsule is considered the thickest basement membrane in the body.

II. Lens epithelium

- Single layer of cells beneath the anterior capsule extending to the equator. It is not lining the posterior capsule.
- They are cuboidal in appearance (Columnar at the equator).
- Function:
 - Forming the lens fibers.
 - Secreting the capsule.
 - Important role in metabolism.

III. Lens substance

- Constituting the main mass of the lens, formed of densely packed lens fibers with very little extracellular spaces.
- Divided into: the nucleus & the cortex.
- **Nucleus:** It is divided into four parts:
 1. Embryonic (Innermost): Containing the oldest fibers that have been formed during intrauterine life. Newer fibers are added concentrically.
 2. Fetal.
 3. Infantile.
 4. Adult (Outermost).
- **Cortex:** Containing the outer concentric layers of the lens fibers.

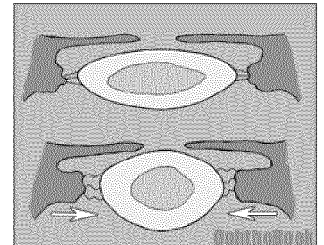
- **Sutures:** They are formed by the overlap of ends of lens fibers, before birth. These are anterior suture, that looks like an erect Y and a posterior one that looks like an inverted Y.
- **Composition:**
 - **Water 65%**
 - **Proteins 34%** (*The highest protein content in the body*).

Metabolism

- The lens is avascular structure, deriving nutrition from the aqueous humour.
- The lens depends mainly on anaerobic oxidation of glucose. This requires hydrogen carriers as Vit. C & glutathione, *the absence of which may play role in pathogenesis of cataract.*

Function of the Lens

1. **Refraction:** 18 Diopters of the refractive power of the eye.
2. **Accommodation:** Accommodation is achieved by changes in the curvature of the lens, through contraction of the circular fibers of the ciliary muscles.
3. **UV rays absorption:** The lens plays an important role in absorption of the harmful UV rays, preventing it from reaching the retina.



Cataract

Definition

Any congenital or acquired Opacification of the lens substance or capsule, irrespective of its effect on vision.

Classification

I. Etiological classification:

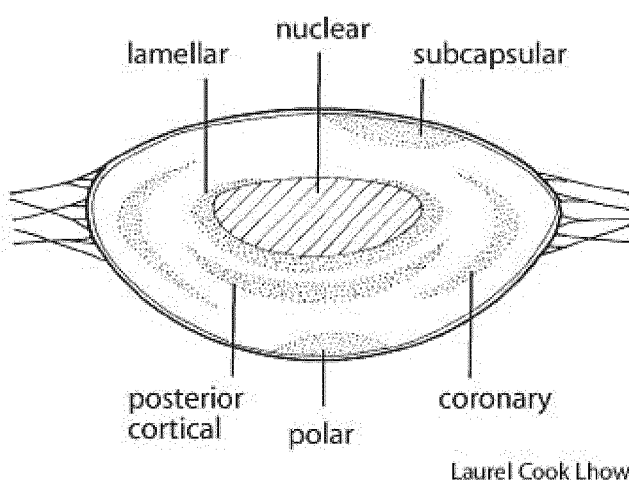
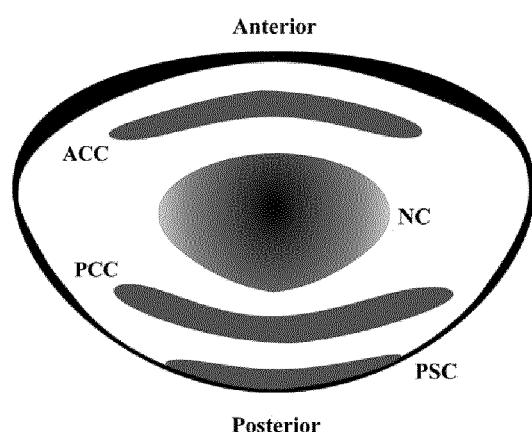
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|-------------------|-----------------|
| 1. Developmental. | 3. Traumatic. |
| 2. Senile. | 4. Complicated. |

II. According to age:

Hard cataract	Soft cataract
In a person above 25-30 years of age.	In a person below 25 years of age.
There is a hard nucleus.	There is no hard nucleus.
Only the cortex can be aspirated, but the hard nucleus has to be removed.	Treated through total aspiration of the lens matter.

III. According to layer affected:

1. Sub-capsular: Anterior & posterior.
2. Cortical: Anterior & posterior.
3. Nuclear.



Pathology

The lens, undergoing opacification, undergoes two pathological changes:

1. **Hydration:** *↑↑ water content of the lens.*
2. **Coagulation:** *The lens proteins undergo coagulation.*

Developmental cataract (Congenital)

Definition

Type of cataract, discovered at birth, or at early years of life.

Etiology

1. **Hereditary:** 25% of cases. It is usually autosomal dominant.
2. **Intrauterine infection:** Especially rubella. Other causes may be cytomegalovirus, herpes simplex & varicella.

3. **Metabolic:** Especially **galactosemia**.

4. **Malnutrition.**

Morphologic types

1. Anterior polar cataract.
2. Posterior polar cataract.

3. Lamellar (Zonular cataract).
4. Total cataract.

1. Anterior polar cataract:

- **Etiology:**

1. **Intrauterine:** Delayed formation of the anterior chamber during the intrauterine life $\Rightarrow$ long contact between the lens & the cornea.

2. **After birth:** Central corneal perforation.

- **Handicapping:** Usually it has little effect on vision.

2. Posterior polar cataract:

- **Etiology:** Remnants of the hyaloid artery.
- **Morphology:** Small disc-shaped opacity at the posterior pole.
- **Handicapping:** The opacity is small in size; however, vision is severely affected, as **the opacity is near the nodal point of the eye.**

3. Lamellar (Zonular) cataract:

- **Definition:** Lens opacity, involving one or more of the lens layers, while the rest of the layers are clear.
- **Etiology:**
 1. Hereditary.
 2. Maternal malnutrition (*Especially vit. D & Ca⁺⁺ defecency*).
The child may show evidence of rickets & abnormal teeth enamel.
- **Morphology:** Central white disc, with spokes, resembling a steering wheel of a ship.

4. Total cataract:

- **Etiology:** Mother infection with rubella, during the 1st trimester. Usually associated with other anomalies, especially heart anomalies.
- Surgical ttt is postponed after the age of 2 years, to avoid post-operative viral uveitis.

5. **Other types:** Disciform, punctate, sutural, coronary & fusiform.

Symptoms: Reported by the mother:

1. White pupil (**Leukocoria**).
2. Defective vision (The baby holds any object very near to his eyes).

Signs

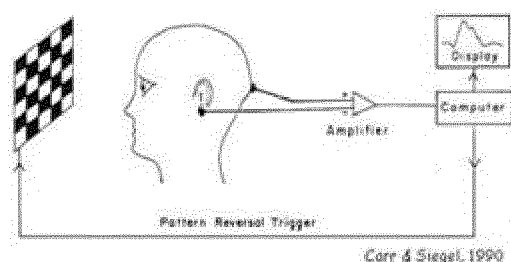
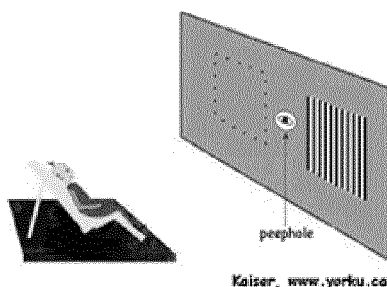
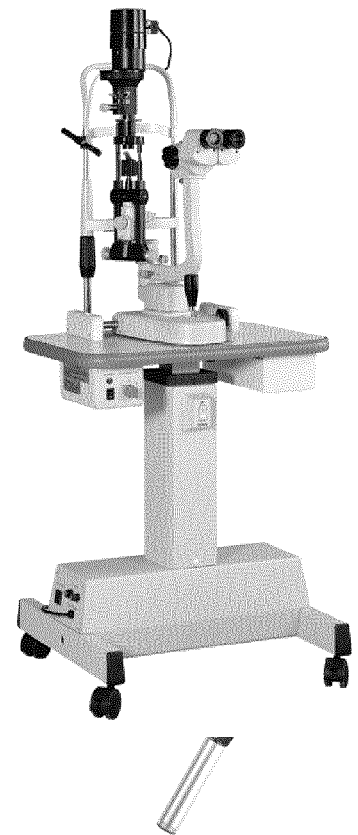
1. **Opacity of the lens:** Opacity of the lens is described by:

- Direct illumination: To detect the shape.
- Oblique illumination: To detect the layer affected (Depth).
- Red reflex.

2. **Visual assessment:**

- Preferential looking test.
- Visual Evoked Potential (VEP).

3. **Referral to a pediatrician & tests** to determine any metabolic cause as galactosemia. Or any associated systemic congenital anomaly.



N.B. Examination of a case of cataract:**1. Examination of cataract:**

- Dilatation of the pupil.
- Direct illumination.
- Oblique illumination.
- Red reflex.
- Slit lamp biomicroscopy.
- Evaluation of cataract density.



2. Full ocular examination: For detection of associated congenital anomalies (e.g. buphthalmos) & detection of complications.

3. Systemic examination: In suspected systemic congenital anomalies, the patient may be referred to a pediatrician.

Complications

1. Dense bilateral opacities $\Rightarrow$ **Fixation nystagmus.**

2. Unilateral opacity may lead to:

- **Amblyopia.**
- **Squint.**

Treatment**1. Unilateral cases:**

- Should be operated as fast as possible, to avoid amblyopia.
- Post-operative vigorous amblyopia therapy.

2. Bilateral cases: The decision to operate or not depends on:

- Density of the opacity.
- Symmetry of the opacity.
- Visual acuity of the child.

Timing of surgery:

- **Bilateral dense:** Early surgical interference is mandatory to avoid fixation nystagmus.
- **Bilateral partial:** May be delayed.
- **Unilateral dense:** Early interference.
- **Unilateral partial:** Observation with correction of the refractive error can be sufficient without need for surgery.

Surgical procedures:

1. **Irrigation-aspiration:** Aspiration of the lens matter with simultaneous irrigation with saline.
2. **Pars plana lensectomy:** Removal of the lens cortex, capsule & the anterior vitreous, using a vitrectomy machine.

Bilaterally faint opacities	Asymmetrically dense cataract (Denser in one eye)	Symmetrically dense cataract
Delay surgery to school age if the visual acuity is 6/18 or more. This is seen in zonular cataract.	Bilateral cataract removal, starting with the denser eye, to prevent amblyopia.	Operated as fast as possible to avoid fixation nystagmus. Firstly operate on one eye, followed by the second within few days period.

N.B. How to detect the density of the congenital cataract?

1. The opacity is considered dense if occupying 3mm or more of the central visual axis.
 2. Visualization of the fundus by both the direct & indirect ophthalmoscopy.
3. **Visual rehabilitation:** As early as possible after surgery:
- Contact lenses.
 - Spectacles: In certain conditions:
 - **BILATERAL APHAKIA** &
 - Contact lens intolerance.
 - Secondary IOL implantation: There must be good capsular support for the IOL.

4. **ttt of amblyopia.**

Senile cataract

Definition

Bilateral progressive opacification of the lens, affecting the elderly who are **not suffering from local or systemic diseases.**

Etiology: The exact etiology is unknown, but theories include:

1. Disturbance of the capsular **permeability**.
2. Disturbance of the lens **metabolism**:
 - ↓↓ O₂ intake.
 - ↑↑ water content.

3. **Ultraviolet rays.**
4. **Endocrinal disturbances** accompanying aging.
5. **Genetic susceptibility:** Developing cataract at earlier age.

Incidence

- **Sex:** Equal in both sexes.
- **Age:** Above 50 years.
- **Side:** Usually bilateral. It may start in one side first.

Classification of senile cataract

1. **Senile cortical cataract:** The lens opacity mainly affects the cortex.

Types:

- Immature.
 - Mature.
 - Hypermature.
 - Intumescent.
2. **Senile nuclear cataract.**
 3. **Senile subcapsular cataract:** Anterior & posterior subcapsular.
 4. **Mixed senile cataract.**

I. Senile cortical cataract: The opacity mainly affects the cortex:

1. **Immature cataract:** (Incipient typical immature):

- The lens is not totally opaque.
- There is still some clear fibers.
- Vision is reduced, but the patient still can see. (Ranging from 6/9 to counting fingers).

Morphology:

1. **Cuneiform:** Anterior cortical wedges of opacity. The red reflex appears as dark sectors (Corresponding to the opacity) against red background.

2. **Cupuliform:** Sheet in the posterior cortex.

2. **Mature cataract:**

- Totally opaque lens, with grayish white pupil (Leukocoria).
- Vision drops to HM.
- The red reflex is absent.

3. **Hypermature cataract:**

- The totally opaque lens loses water & shrinks in size.

- The capsule is thickened, wrinkled & Ca^{++} particles are deposited on it.
- The anterior chamber becomes deep & the iris becomes tremulous as it loses its posterior support.
- This type of cataract predisposes to phacolytic glaucoma (Due to the phagocytic response of the escaping lens proteins into the aqueous $\Rightarrow$ The swollen macrophages are trapped in the trabecular meshwork $\Rightarrow$ 2ry open angle glaucoma).
- Types of hypermature cataract include:
 1. **Dry, Shrunk, ordinary:** Loss of the cataractous lens water.
 2. **Wet, Morganian type:** It is a rare type, in which the nucleus sinks down inside the lens, due to soft liquefied cortex.

4. Intumescent cataract:

- Occurs in some cases only.
- **Pathogenesis:** The lens becomes swollen, as it draws water from the aqueous.
- The lens opacifies rapidly with **dramatic drop of vision**.
- Shallow **anterior chamber**, due to swollen lens.
- The **lens capsule** appears glistening, with bluish tinge.
- This type of cataract excites **phacomorphic glaucoma** (Block of the pupil by the swollen lens).

II. Senile nuclear cataract:

- Loss of nuclear transparency that affects vision.
- The nucleus acquires a yellowish or even brown colour, due to deposition of tryptophan-derived pigments.

- This has to be differentiated from the physiological lens sclerosis:

Physiological lens sclerosis	Senile nuclear cataract
• Normal red reflex. • Normal visual acuity in relation to the person's age. • Normal day vision	• The red reflex shows a red ring around a black central opacity. • Markedly affected visual acuity. • Defective day vision.

Symptoms of senile cataract

1. **Gradual, progressive, painless diminution of vision.**
2. Visualization of **fixed black spots** in the visual field.
3. **Index myopia $\Rightarrow$ 2nd sight of the aged:** this may initially enable the patient to read without his reading glasses.
4. **Glare:** As the light scatters on the lens opacity.
5. **Unilateral diplopia:** Due to sectorial changes in the refractive index of the opacified & clear sectors of the lens $\Rightarrow$ distorted retinal image.
6. **In cortical cataract:** The patient suffers from night blindness, as the opacity prevents light from entering to the peripheral retina.
7. **In nuclear cataract:** $\Downarrow$ vision during day time & in bright light, due to miosis (Elicited by light) which limits the pupillary area to the opacified part.

Signs of senile cataract

1. **Direct illumination:** Showing the morphology of the opacity.
2. **By oblique illumination:**
 - Immature cataract: Incomplete gray opacity.
 - Mature cataract: Complete grayish opacity.
 - Intumescent cataract: Glistening capsule with shallow anterior chamber.
3. **Red reflex:** This confirms the type of opacity.

	Hyperature	Mature	Intumescent	Incipient
Vision	Hand movement (HM)			↓↓
Anterior chamber	Deep	Normal	Shallow	Normal
Iris	Tremulous	Normal	Pushed forwards	Normal
Lens	Shrunk	Completely opaque	Swollen with water vacuoles	Opaque sectors
Capsule	Thickened	Normal	Glistening	Normal
Red reflex	Absent			Dark sectors against red background
IOP	Phacolytic glaucoma	Normal	Phacomorphic glaucoma	Normal

Investigations in a case of cataract

- 1. Visual acuity.**
- 2. Fundus examination:** To detect any retinal or optic nerve disease. In mature cataract, it is impossible to see the fundus, so carry out the retinal function tests ⇒
- 3. Retinal function tests:**
 - Color vision.
 - Light projection.
 - Pupillary light reflex.
 - Ultrasonography.
 - Visual Evoked Potential (VEP).

Differential diagnosis

Other causes of gradual, painless diminution of vision:

1. Primary Open Angle Glaucoma (POAG).
2. Dry Age-Related Macular Degeneration (ARMD).
3. Primary optic atrophy.
4. High myopia.
5. Senile cataract has to be differentiated from other types of cataract, especially, complicated cataract.

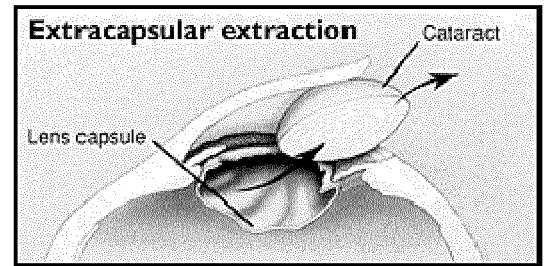
Treatment

Surgery is the only treatment for lens opacities. The patient should be operated on when cataract interferes with his daily activities.

I. Surgical techniques:

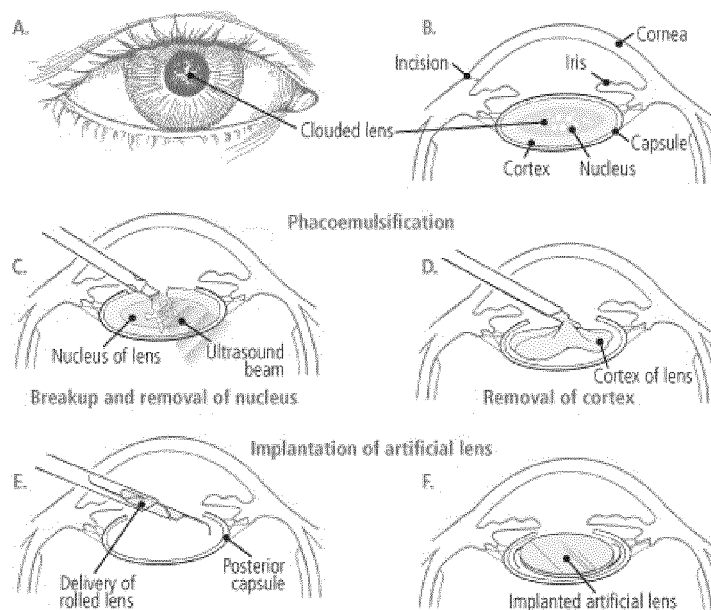
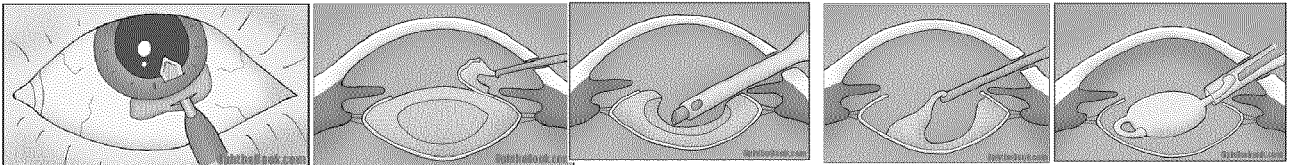
1. Extra-Capsular Cataract Extraction (ECCE):

- Removal of a circular area of the anterior lens capsule.
- Removal of the nucleus.
- Aspiration of the cortex.
- Leave the posterior capsule intact.



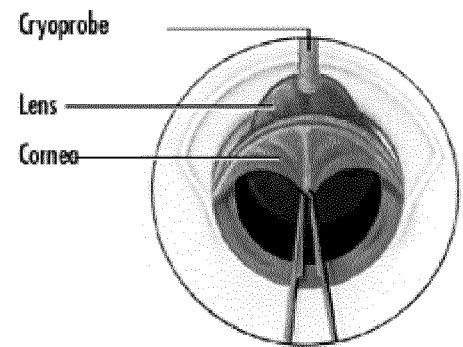
Methods of hard nucleus removal:

- Removal through a large section (6-8mm), either in the cornea or at the limbus.
- Phacoemulsification: Using a special ultrasound machine, the hard nucleus is emulsified, then aspirated. This is accomplished through a 3mm corneal or limbal incision.



2. Intra-Capsular Cataract Extraction (ICCE):

- Zonulysis.
- The lens is removed within the capsule.



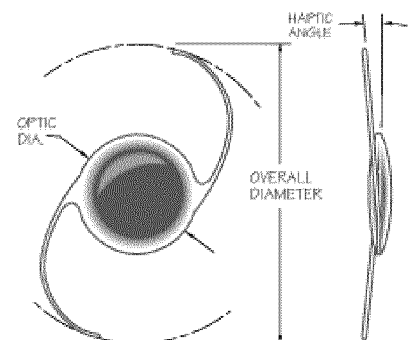
II. Visual rehabilitation after cataract operation:

1. **Spectacles:** Glasses can not be used in unilateral aphakia, as they cause magnification of the retinal image by 33%, which will cause anisokonia $\Rightarrow$ diplopia.
2. **Contact lenses:** CL cause magnification of the retinal image by only 6%, but they can not be used in uncooperative patients or in those who can't tolerate it.
3. **Intra-Ocular Lens implantation (IOL's):** IOL's cause magnification of the retinal image by only 1% or even less.



Types of IOL's:

- **Posterior Chamber IOL (PC IOL):** After ECCE.
- **Anterior Chamber IOL (AC IOL):** After ICCE, as there is no posterior capsule to support the PC IOL.
- **Rigid IOL:** In large section ECCE.
- **Foldable IOL:** After small incision cataract surgery, as phacoemulsification.



Posterior Capsule Opacification (PCO)	After cataract
• Incidence: Few years after ECCE, with or without IOL implantation. • Cause: Opacification of the Posterior capsule. • ttt: YAG laser capsulotomy.	• Incidence: Immediately after cataract surgery. • It is formed of: 1. Parts of the anterior & posterior capsule. 2. Left fibers. 3. Proliferation of the remaining subcapsular epithelium. • ttt: 1. No interference if vision is not affected. 2. Surgical intervention, if it affects vision.

Complicated cataract

Definition

Lens opacification, due to local ocular disease or a systemic one. This type occurs at any age.

Etiology

A. Local causes:

1. Chronic iridocyclitis or chorioretinitis.
2. Long-standing retinal detachment.
3. Glaucoma.
4. Retinitis pigmentosa.
5. Degenerative myopia.
6. Intraocular tumours.
7. Topical medications: Steroids, pilocarpine & adrenaline eye drops.

B. Systemic causes:

1. Diabetes Mellitus: This may be in one of the following forms:

A. True diabetic cataract (Snow flake cataract):

- A. Young, uncontrolled diabetic.
- B. Early: ill-defined flecks opacities appear under the anterior & posterior capsules.

C. Rapid progression if diabetes is not controlled.

B. Presenile cataract: Similar to senile cataract, but occurring in a younger age in diabetics.

2. Hypoparathyroidism.
3. Galactosemia: Preventable type of cataract.
4. Irradiation: Infrared, X-ray, microwaves & high voltage electric currents.
5. Toxicity with naphthalene, thallium or ergot.
6. Systemic drugs: Prolonged steroids & amiodarone.
7. Heavy ankylostoma infestation.

Pathogenesis

Interference with the lens metabolism.

The posterior capsule is affected earlier, due to:

1. Being thinner.
2. There is no lens epithelium at the posterior capsule.

Morphology

1. Posterior cortical cataract:
 - ❖ Early stages: Rosette-shaped.
 - ❖ Late: The entire lens is affected.
2. Slit lamp examination: polymorphatic luster of the posterior capsule.
3. If cataract is due to uveitis, slit lamp examination can detect the following:
 - ❖ Posterior synechiae.
 - ❖ Keratic precipitates (KPs).
4. The density of opacity is disproportionate to the patient's vision, as the cause may be a local ocular disease.

Management: This depends on age:

1. Management of the cause.
2. Surgical treatment of cataract:
 - a. Soft cataract:
 - ❖ Irrigation-aspiration.
 - ❖ Pars plana lensectomy.
 - b. Hard cataract: Exactly as senile cataracts.

Traumatic cataract

Definition: Lens opacity due to trauma, occurring at any age.

Etiology

1. **Blunt trauma** (Concussion cataract):
 - Cortical, rosette-shaped opacity.
 - The cause is rupture of the posterior capsule.
 - Vossius ring: Circle of iris pigment on the anterior lens capsule, due to impress of the pupillary border of the iris on the lens.
2. **Perforating trauma** ⇒ Rupture of the capsule.
3. **Intra-ocular foreign body (IOFB):**
 - Iron IOFB ⇒ Siderotic cataract.
 - Copper IOFB ⇒ Sunflower cataract.

Management

1. **Meticulous ocular examination:**
 - **Aim:** To detect any other ocular complication to trauma, other than cataract.
 - IOFB should be removed if necessary.
 - Any wound should be properly sutured.
 - Ultrasonography, if the opacity was dense, aiming at detecting vitreous haemorrhage or retinal detachment following trauma.

2. **Cataract extraction** with or without IOL implantation: The same techniques for extraction of soft & hard cataracts.
3. **Regular post-operative follow-up:** For early detection of any late complication of trauma that may affect the eyes.

N.B. Causes of unilateral cataract

1. Traumatic cataract (*Most common cause of unilateral cataract*).
2. Complicated cataract, due to local ocular disease.
3. Congenital cataract (*Less common to cause unilateral cataract*).
4. Early cases of some senile cataract (*As the disease may start in one eye before the other*).

Aphakia

Definition: Absence of the crystalline lens from the pupillary area.

Etiology

1. Congenital: Rare.
2. Posterior dislocation of the lens: As in trauma.
3. Surgical removal: After cataract extraction.

Signs

1. Poor vision.
2. Jet-black pupil.
3. Tremulous iris.
4. Deep AC.
5. One purkinje-sanson image.
6. Scar of cataract surgery, in cases of surgical extraction.
7. Posterior dislocation: The lens is detected by ophthalmoscopy.

Management

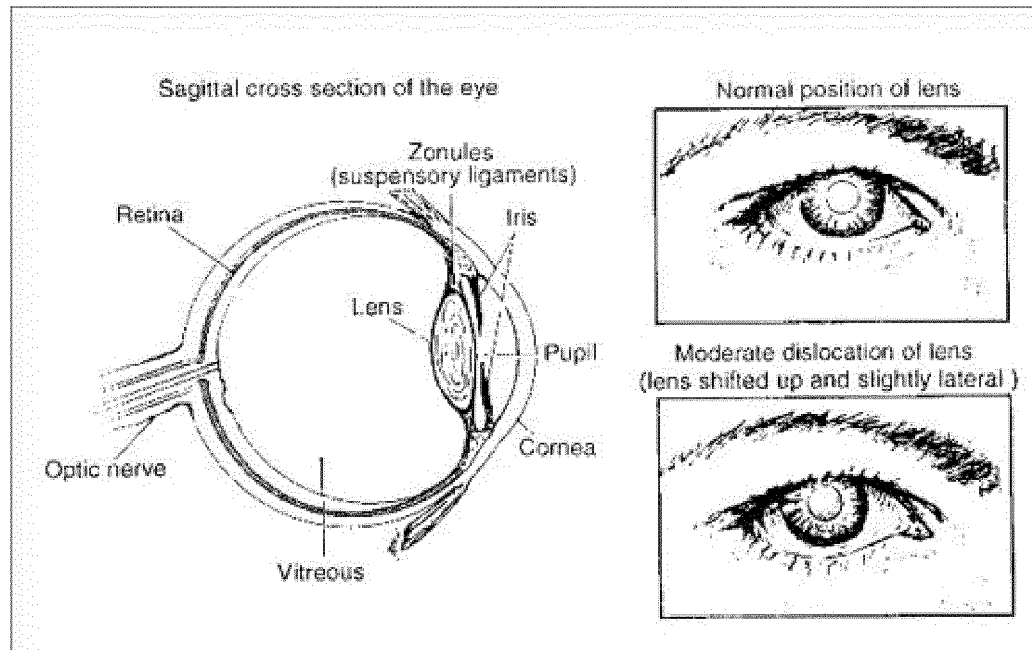
1. Bilateral aphakia: Can be corrected by eye glasses.
2. Unilateral aphakia:
 - Can not be corrected by eye glasses, as this causes anisokonia & binocular diplopia.
 - Corrected by contact lenses or IOL implantation.

Ectopia lentis

Displacement of the lens from its normal position.

This may be:

1. **Subluxation:** Partial displacement of the lens.
2. **Dislocation:** Total displacement of the lens.



1. Subluxation of the lens

Definition

Displacement of the crystalline lens, within the pupillary area, due to tearing of some of the zonules (Not all of them.)

Etiology

1. **Congenital:** Marfan's syndrome (Subluxated lens, Retinal detachment, tall stature & long fingers).
2. **Traumatic.**
3. **Degenerative:** As in hypermature cataract.
4. **Metabolic:** Homocystinuria.

Symptoms

1. **↓ vision** (Due to myopic astigmatism):

- **Myopia:** Relaxation of the zonules $\Rightarrow$ $\uparrow\uparrow$ curvature of the lens.
 - **Astigmatism:** Due to tilting of the lens.
2. **Unilateral diplopia:** As the lens margin is still in the pupillary area, causing the light to be refracted through aphakic portion & another phakic one.

Signs

1. Irregular depth of the AC.
2. Tremulous iris (Iridodonesis).
3. Edge of the lens may be seen across the pupil.
4. The phakic portion appears grayish, while the aphakic portion appears jet black.

Complications

1. Cataract.
2. 2ry glaucoma.
3. Anterior uveitis.
4. Lens dislocation.

Treatment

- If there is no complications: Glasses to correct the error of refraction.
- When complications occur: Extraction of the subluxated lens.

2. Dislocation of the lens

Definition

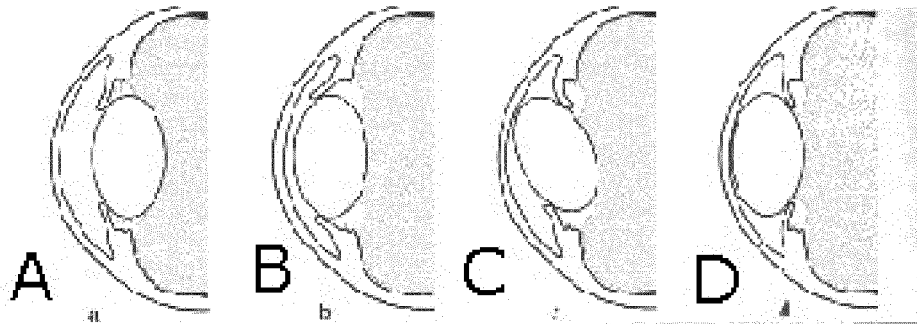
Displacement of the lens from its place due to total tearing or absence of the zonules.

Etiology: Exactly as in subluxation.

Types

1. **Anterior dislocation:** Into the AC.
2. **Posterior dislocation:** Into the vitreous.

3. In very rare cases, the lens was recorded to have displaced to the sub-conjunctival space.



1. Anterior dislocation:

- The lens appears spherical & resembles an oil droplet in the AC.
- **Complications:**
 - 2ry glaucoma: Glaucoma inversus (Worsens on miosis.)
 - Iritis.
 - Corneal decompensation & edema, if left for several weeks.
- **Treatment:** Removal through a corneal incision.

2. Posterior dislocation:

- There are signs of aphakia.
- The lens may be detected by fundus examination.
- **Complications:** Uveitis & 2ry glaucoma.
- **Treatment:** Pars plana vitrectomy.